October 1980

# Solar Europe

Newsletter of the Solar Energy Programme of the European Communities
Issued by the Directorate-General XII for Research, Science and Education

(beginning with No 1, October 1980...

## Introducing "Solar Europe"

This newsletter will give up-to-date information on the EC Solar Energy R & D Programme, led by the Directorate-General XII for Research, Science and Education. This first number has been issued to mark the start of contract work under the Second Programme (July 1979-June 1983). It gives an outline of the programme and a summary of current contracts, with budgets in EUA (European Unit of Account). A conversion table into European currencies is given below.

"Solar Europe" will be distributed to persons actively involved in R & D and related efforts, to science journalists and the interested public. Material contained herein may be reprinted freely, unless otherwise indicated. Please print usual acknowledgement.



Further information is available from:

Commission of the European Communities,
Directorate-General XII for Research, Science and Education,
Rue de la Loi, 200,
B-1049 Brussels.

### European Unit of Account

Equivalent in European currencies as at September 1980

| | | |
|---|---|---|
| Belgium & Luxembourg | F | 40.60 |
| Germany, F.R. | DM | 2.53 |
| Netherlands | Fl. | 2.76 |
| United Kingdom | £ | 0.59 |
| Denmark | Kr. | 7.84 |
| France | F | 5.88 |
| Italy | L | 1204 |
| Ireland | £ | 0.67 |

US $ 1.40

## Highlights of R & D effort on solar energy technologies

With a total budget of 46 million EUA, the second European Communities solar energy R & D programme started on 1 July 1979 and will run to June 1983.

The Commission awards R & D contracts to industry, universities and research institutes, usually after publication of specific calls for tenders in its Official Journal. The contracts provide for up to 50% payment of costs of approved proposals. Co-operation among European institutions is stimulated through joint projects with several EC countries, contractors' meetings, international conferences and workshops. Work started on current contracts in July 1980.

The first programme (1975-1979) fully achieved its objective to initiate, stimulate and strengthen solar energy R & D activities in the Communities, particularly in the fields of:

Solar energy applications to dwellings (Project A);
Thermo-mechanical solar power plants — the helio-electric 1 MWe power plant (Project B);
Photovoltaic power generation (Project C);
Photochemical, photoelectrochemical, photobiological conversion (Project D);
Energy from biomass (Project E);
Solar radiation data (Project F).

In the second programme these broad headings are maintained, and two new activities have been added:

Wind energy (Project G);
Solar energy in agriculture and industry (Project H).

There is however a significant switch in current activities: instead of the earlier exploratory work, main emphasis will be on the development and construction of prototype systems with the aim of identifying any problem areas in systems, increasing the credibility of solar energy, and encouraging its rapid implementation.

In the European Communities, prototypes must, as a general rule, have a minimum critical size if they are to become credible as future large-scale energy sources. Prototypes on a large scale make it possible to seek the cooperation of industry in the Member Countries. Thus European companies will be encouraged to specialize and to cooperate efficiently in the solar energy sector.

The following paragraphs give a brief outline of activities under the second programme.

### Thermo-mechanical solar power plants

"Eurelios", the EC helio-electric 1 MW power plant, which is expected to start up in December 1980 as a world first of its kind, is a striking example of European co-operation. This plant was initiated under the first programme. Technical information is given on page 4.

## 1980 Photovoltaic Solar Energy Conference

**27-31 October 1980**
**Palais des Festivals**
**et des Congrès**

### Cannes, France

The 1980 Photovoltaic Solar Energy Conference is the third to be organized by the European Commission. Submitted abstracts number 230 from 24 countries.

The ambitious goal of large-scale electricity production is a challenge to the international photovoltaic community and the Conference provides an opportunity to assess progress and look ahead. More than 600 participants from all over the world are expected to attend. For the first time, the Conference includes an exhibition of photovoltaic material, which will also be open to the public on Wednesday 29 October.

## ENERGY FROM BIOMASS

**at the**
**Brighton Centre**
**Brighton, England**
**4-7 November 1980**

Organized by the European Commission in co-operation with the UK Department of Energy, and assisted by an international Committee of experts, the Conference will discuss all aspects of the biomass technologies and their utilisation. The Conference will bring together experts from many countries to present and discuss the most recent advances in research, development, demonstrations, design, manufacture, field testing and applications. It will provide an international forum for the formal and informal exchange of new ideas and identification of problem areas.

### Solar heating

Solar heating has a large potential, and the EC effort in this direction complements the important activities already funded by Member Countries under their own programmes. Major thrusts of the EC programme under this heading are on cost-effective heat storage, development and testing of solar heating system models, testing of collectors, solar cooling, and integration of solar energy into dwellings (passive solar heating concepts). Current contracts in this area are summarized on the back pages.

### Photovoltaic power plants

Because they can work even under cloudy skies, photovoltaic plants are the most promising devices for the production of electricity from solar radiation in Europe, including the northern parts.

Research efforts and partial automation have already resulted in cost reductions of silicon photovoltaic panels, and a further cost reduction is confidently foreseen in the next few years. Practical applications are increasing rapidly. The next step is to challenge diesel generators in the 10 kW-100 kW range of independent power plants. Short-term storage of power is technically feasible with batteries, and long-term storage can be provided in many parts of western Europe by combining photovoltaic systems with hydroelectric storage, wind systems or simply the grid.

The objectives of the current plan are to continue R & D efforts on solar cells and arrays so as to reduce costs and increase life-time, and to design and develop a family of photovoltaic power systems with a total power of 1 MW set up as pilot projects for various applications in various European climates.

Specific lines of development work under the current programme in this area may be seen in the summary of contracts under Project C on the back pages. Contracts on pilot projects will be concluded in 1981 and are not yet included on that list.

### Energy from biomass

Large quantities of agricultural waste, chiefly straw, wood residues and wood from under-exploited forests in Europe, as well as liquid wastes from cattle-raising constitute a potential energy source for the future.

The experience of the last few years, both as a result of the European Community's first four-year programme and of the efforts employed elsewhere, has already heightened awareness of the possibilities for the exploitation, for energy purposes, of biomass, either in the form of existing or predicted organic residues or of crops grown specifically for this purpose. Biomass can be employed either directly or by burning, if appropriate, or after conversion as biogas, syngas or other synfuels. Emphasis in the EC R & D programme is on conversion processes. The second programme culminates in a small number of pilot projects. The production of synfuel plants, particularly for the production of methanol from wood, is the main aim of these pilot projects. Some effort is also foreseen on the production of ethanol, biogas and some schemes for biomass growing (wood, catch crops, algae, etc.).

### Photochemical, photoelectrochemical and photobiological processes

More than 30 research laboratories in the EC were involved in the first programme, but rapid breakthroughs cannot be expected in this new kind of research which is mostly of a fundamental nature and involves advanced areas such as microbiology. The general objectives of the current programme are:

Understanding the photoconversion mechanism;

Photochemical production of fuels and/or electricity;

Improvement of hydrogen production via living cells;

Construction of artificial systems based on photosynthesis models.

### Solar radiation data

The current programme includes the production of atlas and data books of solar radiation in the EC for simple design methods, data banks and the development of measuring instruments. The first volume of the European Solar Radiation Atlas which appeared in 1979 is reviewed on this page.

### Wind energy

Research is envisaged on site evaluation and general potential of wind energy in the EC; wind turbines, in particular the development of new concepts, investigation of wind generators for off-shore utilisation, testing under various climatic conditions; wind generators combined with photovoltaic generators, and biomass production plants, etc.

### Solar energy in agriculture and industry

Agriculture and industry will both eventually be able to use the components developed for solar heating of dwellings, although their size will be different and attention must be paid to special aspects such as the demand for high-temperature heat in industry. The current programme envisages assessment of energy needs and potential solar applications, development of solar systems models, and monitoring of advanced systems, e.g. green houses, drying systems, steam generators.

**Funding of projects** in the second solar energy R & D programme, (in million European Units of Account) 1979-1983

| | Project total | Pilot projects (included in Project total) |
|---|---|---|
| **Project A** Solar Energy Applications to Dwellings | 8.3 | — |
| **Project B** Thermo-mech. Solar Power Plants | 4.7 | 4.2 "Eurelios" |
| **Project C** Photovoltaic Power Generation | 15.9 | 7.0 "30kW-300kW pilot plants" |
| **Project D** Photochemical ... Processes | 2.6 | — |
| **Project E** Energy from Biomass | 7.4 | 3.5 "Methane from wood etc." |
| **Project F** Solar Radiation Data | 2.0 | — |
| **Project G** Wind Energy | 1.0 | — |
| **Project H** Sol. E. in Agric. and Industry | 0.7 | — |
| Management and Reserve | 3.4 | — |
| Total | 46.0 | 14.7 |

## EUROPEAN SOLAR RADIATION ATLAS

Volume I:
Global Radiation on Horizontal Surfaces

Edited by
W. PALZ, Commission of the European Communities

Compiled by
F. KÄSTEN and H.J. GOLCHERT, Deutscher Wetterdienst, Meteorologisches Observatorium Hamburg

Final cartography by
C. PERRIN de BRICHAMBAUT and L. BIZERAY, Météorologie Nationale, Observatoire de Trappes

Comprehensive and reliable data on solar radiation in Europe have been made available to the general public for the first time in this initial volume of a series to be prepared by the Commission of the European Communities over the next few years, in colloboration with the Meteorological Offices in the Member States.

The Atlas contains 17 maps showing global radiation on horizontal surfaces for the area of the European Communities and some adjacent regions. The maps are derived from data from 56 meteorological stations; these data are also presented separately in the form of tables.

The maps record monthly and annual averages and maximum and minimum levels of total solar radiation reaching the surface every day; they are based on reliable measurements covering a period of ten years, and provide a detailed record of the current state of knowledge in this area.

The Atlas constitutes an important source of information for anyone in Europe with an interest in solar energy. Because of its clarity and the fact that it uses conventional energy units, the Atlas can be used directly for assessing local potential for utilizing and building solar energy facilities. The Atlas is also an appreciable contribution towards better knowledge of climatic conditions in the European Community countries. Further volumes are planned, in particular for solar radiation on vertical and sloping surfaces and for direct solar radiation.

The Atlas is available in English, French, German, Italian, Dutch and Danish versions, from the publisher: W. Grosschen-Verlag, D46 Dortmund, Südwall 15, Federal Republic of Germany, price DM 14.80.

# EURELIOS

## The 1 MW (el) Helioelectric Power Plant of the European Community

### Concept

182 sun tracking mirrors (heliostats) concentrate the solar rays onto a steam generator located on top of a 55 m high central tower. The steam drives a turbogenerator which delivers its electrical energy into the existing grid of the Italian National Utility ENEL. A heat storage system enables the power plant to operate without solar energy input for about half an hour, to allow for the passage of clouds.

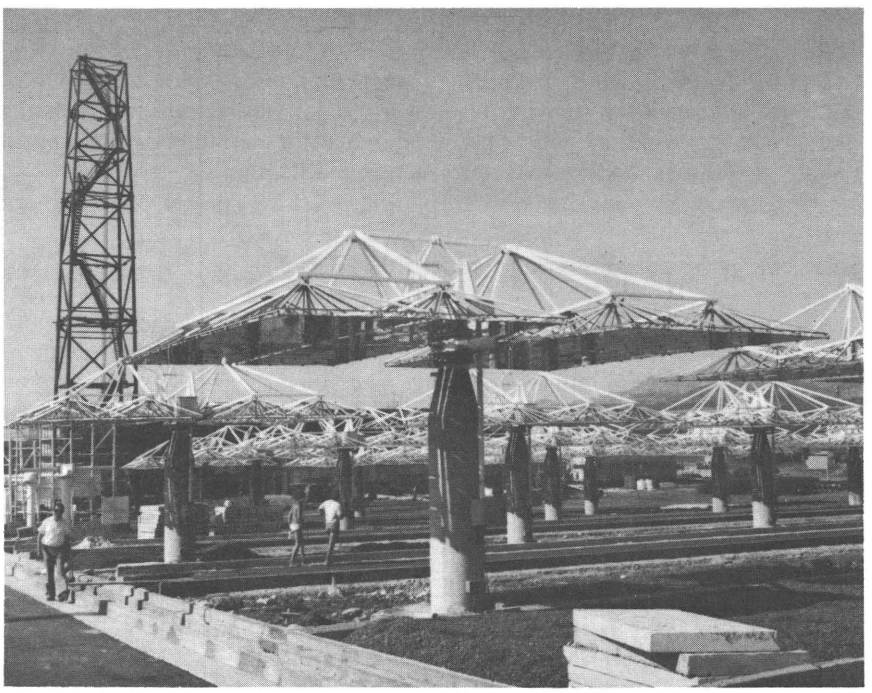
### Heliostats

The mirror fields is made up of two types of heliostats, in order to gain experience with small (MBB) and large (CETHEL) heliostats.

The **receiver,** designed by G. FRANCIA, is a once-through, cavity type boiler generating steam of 512°C, 64 at, fed to the turbogenerator. Its high efficiency of above 90% is due to built-in antiradiating devices.

**Technical data of EURELIOS**

| | |
|---|---|
| Nominal rating: | 1 MW(el) |
| Thermal power: | 4,8 MW |
| Mirror surface total: | 6 216 m² |
| Heliostals: | 112 with 23 m² mirror surface (MBB)<br>70 with 52 m² mirror surface (CETHEL) |
| Steam condition: | 512°C, 64 ata |
| Tower height: | 55 m |
| Heat storage: | 1/2 hour (molten salt + hot water) |



EURELIOS is a project of the Commission of the European Communities, Directorate-General for Research, Science and Education with the participation of three member countries: France, Germany, Italy.

EURELIOS is built by an industrial Consortium consisting of AMN-ANSALDO Italy, CETHEL France, MBB Germany and ENEL Italy.

EURELIOS is expected to start up in December 1980, its location is at ADRANO (Catania), Sicily, Italy.

It will be the world's first large scale helioelectric power plant to be connected to an existing utility grid.

# Current contracts

Most contracts run from July 1980 to June 1983
The EC contribution does not exceed 50% of total costs

## Project F: Solar radiation data

Contractors are the national meteorological services of member countries of the EC and some solar energy laboratories. The total for all contracts approved under Project F is approximately 1.3 million EUA.

**Action 1:** International intercomparison of national radiation instrument standards. (No contracts at the moment).

**Action 2:** Development and production of Test Reference Years (TRY) formation of a library for the different climatic zones as defined by action 3.1. Development and production of Short TRY's (SRY).

| Organisation | Title |
|---|---|
| Thermal Insulation Laboratory, Technical University of Lyngby (DK) | Development of SRY for systems and buildings (action leader) |
| The Technical Institute, Director Morten Knudsen (DK) | SRY for buildings |
| Department of Mechanical Engineering, TH Delft (NL) | SRY for annual solar heat gain of buildings |
| Institut Royal Météorologique Bruxelles (B) | Library of TRY's for different climatic zones in the EC |
| Faculté Polytechnique de Mons (B) | Synthetic TRY |
| Analysis and Development of Energy Systems (ADES), Rome (I) | Statistical representation of meteorological data |

**Action 3.1:** Improvement of the EC atlas of irradiance on a horizontal plane, definition of climatic zones for the EC.

| Organisation | Title |
|---|---|
| Meteorologisches Observatorium Hamburg Deutscher Wetterdienst (D) | Atlas of global radiation on horizontal surfaces; definition of climatic zones (action leader) |
| Institut Royal Météorologique (B) | Data from boundary countries of EC |

**Action 3.2:** Development of methods to calculate the irradiance on tilted planes by using other meteorological data. Production of an atlas.

| Organisation | Title |
|---|---|
| Institut Royal Météorologique (B) | Improvement of simple calculation methods for inclined surfaces (action leader) |
| Meteorologisches Observatorium Hamburg (D) | Analysis of short-term data of irradiance on inclined planes |
| Koninklijk Nederlands Meteorologisch Inst. (NL) | Climatology of solar irradiance |
| Sean McWilliams/Irish Meteorological Service (IR) | Statistical analysis of measurements of radiation on inclined surfaces |
| Météorologie Nationale, Paris (F) | Climatological study of the diffuse radiation on inclined surfaces |
| Meteorological Office, Bracknell (GB) | Methodology of estimating diffuse radiation from sunshine duration. Analysis of the variations over UK of coefficient of the Angstrom equation |
| Department of Building Science, University of Sheffield (GB) | Production of data to prepare an atlas of radiation on inclined surfaces |
| Institut für Lichttechnik TU Berlin (D) | Ditto (combined with Sheffield) Angular distribution of global radiation |
| CNRS/Laboratoire d'Energetique Solaire Odeillo (F) | Statistical Analysis of the components of global radiation on differently oriented planes |

**Action 3.3:** Representation of meteorological information by statistical methods.

Production of cumulative frequency distributions.
Analysis of correlation distributions for irradiance and other meteorological parameters, e.g. air temperature.

Analysis of time sequences of irradiance

| Organisation | Title |
|---|---|
| Météorologie Nationale, Paris (F) | Correlation between global radiation and temperature. Cumulative frequency distributions of global radiation on inclined surfaces (action leader) |
| École des Mines, Sophia Antipolis (F) | Library of cumulative frequency distribution for the global radiation on horizontal and inclined surfaces for EC countries |
| Meteorologisches Observatorium Hamburg (D) | Parametrization of radiation fluxes as function of different meteorological parameters |
| Koninklijk Nederlands Meteorologisch Inst. (NL) | Cumulative frequency distribution for data of the Meteorological service in different orientations |
| CNRS/Laboratoire d'Energetique Solaire Odeillo (F) | Production of Cumulative frequency distribution for data of Odeillo in different orientations |
| Department of Building Science, University of Sheffield (GB) | Correlation of global radiation to atmospheric parameters with respect to heat transfer calculations |

**Action 3.4:** Sensitivity studies of the useful new energy output from solar converters on the quality and completeness of meteorological data sets in use.

| Organisation | Title |
|---|---|
| Faculté Polytechnique de Mons (B) | (Open, pending) (action leader) |
| KFA-IKP/Arbeitsgruppe Solarenergie (D) | Study of the influence of the quality of meteorological data on the calculation of useful energy output from flat plate collectors. Test of the calculation methods by experimental validation. Study of the influence of meteorological parameters on the performance of uncovered collectors |
| École des Mines, Sophia Antipolis (F) | Study of the specific meteorological requirements for calculating the useful energy of medium temperature collectors and photovoltaic devices |

**Action 4.1:** Improvement of radiation measurements in national radiation networks. Improvement of the measurements of the different components of solar radiation (Global, diffuse and direct radiation).

| Organisation | Title |
|---|---|
| Meteorological Office, Brachnell (GB) | Improvement of the measurement techniques for diffuse radiation. Extension of the global, direct and diffuse radiation network (action leader) |
| Meteorologisches Observatorium Hamburg (D) | Improvement of measurements of diffuse sky radiation |
| Météorologie Nationale, Paris (F) | Intercomparison and calibration of substandard pyranometers. Study of temperature compensation for Kipp & Zonen solarimeters |
| Irish Meteorological Service, Valentia (IR) | Improvement of Irish radiation network |
| Istituto Fisica Atmosfera-CNR, Rome (I) | Data elaboration of sunshine, global radiation, air temperature and wind. Installation of network for direct radiation |
| Danish Meteorological Institute (DK) | Maintenance, data processing and calibration of the Danish radiation network |
| Koninklijk Nederlands Meteorologisch Inst. (NL) | Data production by measuring with the radiation equipment in De Bilt |

**Action 4.2:** Special measurements.

Spectral distributions.

Measurements of the terrestrial radiation.

Measurements of turbidity.

Measurements of circumsolar radiation.

| Organisation | Title |
|---|---|
| Météorologie Nationale, Paris (F) | Climatological study of the atmospheric radiation and turbidity (action leader) |
| Irish Meteorological Service, Valentia (IR) | Measurement of reflected radiation from ground |

| Organisation | Title |
|---|---|
| Institut Royal Météorologique (B) | Measurement of spectral distribution by filter techniques (Continuation pending) |
| Centro Proviciale di Ecologia e Climatologia, Macerata (I) | Continuation of radiation measurements at different heights |
| Istituto Fisica Atmosphera, Rome (I) | Network for spectral measurements |
| Meteorologisches Observatorium Hamburg (D) | Correlation of atmospheric radiation to vertical profiles of temperature and water vapour |
| Danish Meteorological Institute (DK) | Network for spectral measurements |
| Meteorologisches Institut, Uni Mainz (D) | Circumsolar radiation |
| CNRS/Laboratoire d'Energie Solaire, Odeillo (F) | Albedo investigations |

**Action 4.3:** Use of satellite images.
The development of operational methods using satellite images for the determination of cloudiness, sunshine duration and irradiance.

| Organisation | Title |
|---|---|
| École des Mines, Sophia Antipolis (F) | Heliosat |
| Institut für Geophysik und Meteorologie, Universität zu Köln (D) | Determination of the global radiation and cloudiness from satellite data |
| Institut für Phys. Elektronik, Uni Stuttgart (D) | Satellite image analysis |
| Deutscher Wetterdienst, Zentralamt (D) | Installation of operational procedures for satellite image analysis |
| Southwest Energy Group, Exeter University (GB) | Reference station for satellite data study of variations in Angstrom coefficient |

## Project A: Solar Energy Applications to Dwellings

Emphasis is put on the following coordinated actions:

— collector testing programme (20 participating laboratories)
Coordinator: University College, Cardiff (UK)

— European modelling group for solar heating systems and domestic hot water (12 participating groups)
Coordinator: Denmark's Technical University, Copenhagen (DK)

— Solar pilot test facilities (8 installations throughout Europe)
Coordinator: G. Olive, Paris (F)

— Performance monitoring of solar houses (6 subcontractors)
Coordinator: Energy Conscious Design, London (UK)

Coordinated actions initiated under the auspices of the first programme are already in progress. In the second programme, now current, a total of 1.1 million EUA has been allotted, these contracts started in 1979.

Besides concerted actions, development contracts have been approved for heat storage, solar cooling and high performance collectors.

The total for all contracts approved under these subjects is around 2 million EUA. They result from a call for tenders published in the official Journal of the European Communities on 28 September 1979. Contracts are listed here below:

**Subject I:** Heat Storage, Latent and Chemical.

| Organisation | Title |
|---|---|
| University College Cardiff (UK) | Modelling of thermal storage for solar heating systems. |
| Faculté Polytechnique de Mons (B) | Thermochemical solar energy storage in reversible reactions. Chemical heat pump using ammoniacates. |
| Katholieke Universiteit Leuven (B) | Short-term storage of solar heat from air-cooled solar collectors, using latent heat of melting of parafin in a regenerative storage system, in connection with house heating system with air. |
| Technisch Physische Dienst TNO-TH (NL) | Thermal energy storage system using organic phase-change materials with improved thermal conductivities for storage temperatures between 35° and 120°C. |
| Technical University of Denmark (DK) | Reporting on heat storage units using a salt hydrate as storage medium based on the extra water principle. |

**Subject II:** Heat storage, sensible.

| Organisation | Title |
|---|---|
| Technical University of Denmark (DK) | Seasonal heat storage in underground hot water stores. |
| M.B.B. (D) | Experimental demonstration of a high performance flat plate collector field with iso-thermal heat transport by natural steam flow |
| Univ. de Montpellier II (F) | Étude du stockage de chaleur dans les sols non saturés; réalisation d'une colonne d'essai de simulation de l'évolution d'une couche de sol non saturé utilisé comme zone de stockage. |
| Foundation Waterbouwkundig Laboratorium (NL) | Field test to investigate the performance of an undeep prototype seasonal heat storage system with a heat capacity for 100 houses. |
| ARMINES (F) | Le doublet héliogéothermique de recharge intersaisonnière. |
| University of Sussex (UK) | A salt gradient solar pond for solar heat collection and long-term storage. |

| Organisation | Title |
|---|---|
| Università della Calabria (I) | Système d'emmagasinage à long terme de la chaleur solaire pour le chauffage d'hiver «tout solaire» d'un édifice pour habitations. |
| Cranfield Institute of Technology (UK) | The development and optimisation of cost-effective thermal energy storage system for solar space heating by means of micro-processor controlled test facility. |

**Subject III:** Solar Cooling.

| Organisation | Title |
|---|---|
| Institut de Mécanique Appliquée (B) | Development of an autonomous, free piston, refrigeration unit driven by a Rankine cycle and solar energy. |
| Maschinenfabrik Augsburg Nürnberg AG (D) | Development of a self-sufficient solar cooling plant incorporating concentrating collectors, absorption cooling circuits and energy storage systems. |
| Termomeccanica Italiana (I) | Completion of the construction and acquisition of process data relative to a prototype of a solar energy absorption refrigerating plant (25 000 + 30 000 Kcal/hr) for ambient conditioning and also for cold rooms. |
| ARMINES (F) | Design of an absorption cooling system using solar energy and mechanically self-operating through an integrated expansion motor. |

**Subject IV:** High Performance Collectors.

| Organisation | Title |
|---|---|
| Organisation for Industrial Research TNO (NL) | Development of Cobalt-oxide based spectral-selective coatings for solar energy collectors via an electroplating process. |
| Faculté Polytechnique de Mons (B) | Study and construction of a solar focusing collector using a deformable mirror, in the temperature range 100°-200°C. |
| National Institute for High-Education, Limerick (IR) | Development of improved solar heat-energy absorber surfaces. |
| Ansaldo Meccanico Nucleare (I) | Étude et réalisation prototypique des miroirs cylindro-paraboliques avec l'emploi de systèmes de collage et protection avec PVB. |

## FIRST EUROPEAN PASSIVE SOLAR COMPETITION 1980

In April 1980 the Commission launched a competition on passive solar energy use in buildings. Over one thousand entry forms were sent from all over Europe and more than 220 submissions were received. Prizes are to be presented in the categories of multi-storey housing, clustered housing and single dwellings.

One hundred and six designs selected by the technical assessors will be shown at an exhibition in Brussels, 8, Square de Meeûs (11-21 November 1980).

## Project C: Photovoltaic power generation

The total for all approved contracts under Project C is 3.75 million EUA. All contracts started on 1 July 1980. Tenders were called for on 28 September 1979.

**Subject I:** Silicon cells.

| Organisation | Title |
|---|---|
| *a) Cell process development* | |
| Kath. Un. Leuven (B) | Development of new techniques for single crystal silicon solar cell fabrication. |
| R.T.C. La Radiotechnique Compelec (F) | Study of a mono- or polycrystalline solar cell process, using screen-printing technology. |
| *b) Ion implantation* | |
| Laboratoires de Marcoussis (F) | Optimisation of an ion implantation without mass separation — laser annealing technique in order to continuously produce junctions for polycrystalline silicon solar cells. |
| Lamel (I) | Investigation of potentiality offered by ion implantation as a technique to fabricate high efficiency solar cells. |
| Technical University of Denmark (DK) | Production of solar cells on the basis of low cost silicon by application of ion implantation, laser annealing, and laser-induced diffusion. |
| Stichting voor Fundamenteel Onderzoek der Materie (NL) | Optimization of polycrystalline silicon solar cells produced by ion-implantation or deposition and pulsed laser annealing. |
| *c) Material* | |
| Laboratoires de Marcoussis (F) | Design, construction and optimization on the industrial prototype scale of a furnace able to produce polycrystalline silicon ingots as material for solar cells. |
| Pechiney Ugine Kuhlmann (F) | Fabrication de bandes de silicium en continu pour usage photovoltaïque par une nouvelle méthode de cristallisation. |
| Laboratoire d'Electronique et de Physique appliquée | Three-year programme for the study of substrate and growth related problems in continuous polycrystalline silicon layers achieved by the R.A.D. process. |
| France-Photon (S.A. Moteurs Leroy-Somer) (F) | Implementation of low cost semi-crystalline silicon solar cells and introduction of solar grade poly-silicon. |
| Consortium für elektrochem. Industrie GmbH (D) | Classification of crystal defects in solar base material with diamond lattice. |
| R.T.C. La Radiotechnique Compelec (F) | Optimization of processing conditions of solar cells versus physical properties of relatively low cost silicon ... |
| Ansaldo (I) | Introduction of Silso material of Wacker (10 × 10 cm) in Ansaldo photovoltaic flat panel production. |
| *d) Modules* | |
| Photowatt International (F) | Studies relating to new encapsulation materials. |
| Istituto Guido Donegani (Gruppo Montedison) (I) | Low surface reflecting polymeric materials for photovoltaic encapsulation. |
| JM Chemie (D) | Encapsulation of photovoltaic solar cell modules. |
| Resart-Ihm AG (D) | R & D work on the encapsulation of solar cells with improved potting and cover materials. |

## Subject II: Alternative cells.

| Organisation | Title |
|---|---|
| *a) α - Si* | |
| University of Dundee (UK)<br>Max-Planck-Institut (D) | Amorphous silicon photovoltaic junctions produced by gas-phase doping and implantation |
| CEA/CENG/LETI (F) | Hydrogenated amorphous silicon photovoltaic generator. |
| University of Sheffield (UK) | Development of sputtered thin film amorphous silicon solar cells. |
| Plessey Research Ltd (UK) | Improved amorphous silicon devices. |
| Università di Roma (I) | Preparation, study and characterization of hydrogenated amorphous silicon for photovoltaic cells. |
| *b) CdS - $Cu_2S$* | |
| U.S.T.L., Montpellier (F)<br>E.N.S.C.P., Paris (F)<br>U.H.A., Mulhouse (F)<br>U.A.M., Aix-en-Provence (F) | Studies to improve the efficiency of $Cu_2S$-CdS spray solar cells. |
| École Nationale Supérieure de Chimie de Paris (F) | Electrolytical preparation and conditioning of cuprous sulphide. |
| EMI Ltd (UK) | Electrophoreted thin films for low cost solar cells. |
| *c) CdSe* | |
| Battelle-Institut, Frankfurt (D) | R & D work aimed at the development of a cadmium selenide solar cell for the direct terrestrial transformation of solar energy into electrical energy. |

## Subject III: System studies.

| Organisation | Title |
|---|---|
| *a) Pumps* | |
| HOLEC Research (NL) | Optimisation research into a complete photovoltaic generator/consumer appliance system employed for small independent electricity supply systems, deep-water and surface-water pumps and cathodic protection. |
| *c) Subsystem development* | |
| I.D.E. Industrie Développement Energie (B) | A power conditioning interface for a photovoltaic mini utility. |
| *d) Combined thermal/PV systems* | |
| Société Européenne de Propulsion (F) | Capteur mixte thermique et photovoltaïque à concentration. |

## Subject IV: Concentration.

| Organisation | Title |
|---|---|
| *a) General* | |
| Phoebus (I) | Test of photovoltaic concentrator |
| CNRS/Pirdes (F) | Test and demonstration of concentrating photovoltaic generators Sophocle under mediterranean climatic conditions. |
| Leonhardt, Andrä und Partner Beratende Ingenieure GmbH (D) | Development of concentrator photovoltaic systems of economic viability using highly concentrating spherical metal membrane glass laminated mirrors for 500 W. |
| *c) Fluorescent concentration* | |
| Fraunhofer Gesellschaft zur Förderung der angewandten Forschung (D) | Solar energy conversion on the basis of fluorescent planar concentrators. Set-up of a test collector with 20-30 W power output. |
| *d) Beam splitting* | |
| Universität Stuttgart (D) | Holographic thin film system for multijunction solar cells. |
| ENEL (I) | High concentration PV 100 W module making use of spectral splitting and Si-GaAlAs coupled cells. |

# Project D: Photochemical, Photoelectrochemical, Photobiological processes

The total for all approved contracts under Project D is 2 million EUA. Each contractor receives a budget of 80 000 EUA which permits payment of a post-doctorate from July 1980 to June 1983.

## Subject I: Photochemistry.

| Organisation | Title |
|---|---|
| Members of the Royal Institution of Great Britain (UK) | Development of a process for the sensitised photochemical dissociation of water by sunlight. |
| University of Dublin, Trinity College (EIR) | Polymer-bound porphyrins and polymer-bound coordination compounds as converters of solar energy into chemical fuels. |
| Central Organisation for Applied Scientific Research (NL) | Development of a practical process for the production of hydrogen by photochemical cleavage of water with visible light and homogeneous and/or heterogeneous catalysts. |
| Università degli Studi, Bologna (I) | Photochemical conversion of solar energy by means of non-biological systems involving coordination compounds. |
| Centro di Studio sulla Fotochimica e Reattività degli Stati Eccitati dei Composti di Coordinazione (del C.N.R.) (I) | Transition metal chelates as photocatalysts for the chemical conversion of solar energy. |

## Subject II: Photoelectrochemistry.

| Organisation | Title |
|---|---|
| CNRS (F) | Photo-intercalation: a new process combining the conversion and the storage of the solar energy. |
| TNO, Division of Technology for Society (NL) | Photoelectrochemical production of hydrogen from water and of methanol from carbon dioxide. |
| Fritz-Haber Institut (D) | Semiconductor electrodes in contact with aqueous and non-aqueous redox-electrolytes for photovoltaic solar energy conversion. |
| University of Oxford (UK) | Development and characterization of new electrode materials for use in photoelectrochemical cells designed to convert solar energy to chemical energy. |

### Subject III: Photobiology.

| Organisation | Title |
|---|---|
| *(a) Mechanisms* | |
| The United Breweries Ltd (DK) | Genetic manipulation of photosystem I and II in chloroplast agents. |
| University College, London (UK) | The mechanism of electron transfer in photosynthetic reaction centres and oxygen evolution by plants. |
| CEA (F) | The mechanism of photosynthetic oxygen evolution: study of the primary photoreactions and of electron carriers. |
| Université de Liège, Laboratoire de Photobiologie (B) | Immobilisation of chloroplasts, chloroplast membrane fractions and plant cells, and stabilisation of the photosynthetic activities for the photoproduction of hydrogen. |
| University of Osnabrück (D) | Water splitting with visible light by the photosynthetic apparatus of green plants — structural and functional analysis. |
| *(b) Cells and genetics* | |
| Institut de Biologie Physico-Chimique (F) | Applications of genetical methodology to the study of the photosynthetic process. |
| Università degli Studi di Bologna (I) | Photobiological hydrogen production by facultative photosynthetic bacteria: maximization of the rate of $H_2$-evolution by selection of mutant strains deficient in hydrogenase activity or impaired in respiratory electron transport. |
| University of Dundee (UK) | $H_2$ production in air from sunlight and water using $N_2$-fixing cyanobacteria. |
| Université Scientifique et Médicale de Grenoble (F) | Photoproduction of $H_2$ and $NH_3$ by photosynthetic bacteria. |
| University of Liverpool (UK) | The amplification of hydrogenase activity in photosynthetic prokaryotes by mutation and by application of recombinant DNA technology and cloning procedures. |

### Subject IV: Combined systems.

| Organisation | Title |
|---|---|
| Agricultural University, Wageningen (NL) | Immobilization of hydrogenase systems for the photochemical, photovoltaical and photobiological production of hydrogen. |
| University of London King's College (UK) | Biophotolysis of water for hydrogen production via natural and artificial catalytic systems. |
| Université de Technologie de Compiègne (F) | Stabilization of biological photosystems: continuous reactor use for hydrogen production through biophotolysis of water. |
| National Institute of Applied Sciences of Toulouse (F) | Use of immobilized hydrogenase for hydrogen production. |
| Bureau de Recherches Géologiques et Minières (F) | Photodecomposition of water in artificial membranes constructed with layer lattice silicates and with colloidal oxides. |
| Ruhr-Univ. of Bochum (D) | Photosynthetic hydrogen evolution in algae and in reconstituted systems from algae and chloroplasts, including the design of a chloroplast battery. |

## Project E: Energy from biomass

The total for all approved contracts under Project E is around 3.24 million EUA. All contracts started on 1 July 1980.

### Subject I: Agricultural wastes, energy crops.

| Organisation | Title |
|---|---|
| Institut National de la Recherche Agronomique (F) | Energy production using straw and animal wastes as feedstocks. |
| Natural Environment Research Council (UK) | An experimental assessment of native and naturalised species of plants as renewable sources of energy in Great Britain. |
| University of Reading (UK) | Experimental studies on the growth of fuel crops in the time interval between normal harvesting and planting of food crops. |
| C.N.E.E.M.A. (F) | Joint research and development work towards energy production from Donax-Reed crops (Canne de Provence). |

### Subject II: Forestry, wood wastes.

| Organisation | Title |
|---|---|
| University of Aberdeen (UK) | An experimental study of short rotation forestry for energy. |
| Forestry Commission (UK) | An experimental study of coppiced trees as energy crops. |
| Institut National de la Recherche Agronomique (F) | Sélection et création de matériel végétal forestier à croissance initiale très rapide en vue de produire le maximum de biomasse. Création de taillis à courte révolution. |
| Ente Nazionale Cellulosa e Carta (I) | Emploi de la biomasse que l'on peut obtenir des taillis pour combustibles, pâtes à papier et panneaux. |
| An Foras Taluntais (EIR) | The production of energy from short rotation forestry. |
| Irish Peat Development Authority (EIR) | Design, build and test short rotation forestry harvester chipper. |
| C.N.E.E.M.A. (F) | Etude et réalisation d'un matériel pilote de récupération de rémanents d'exploitation forestière. |

### Subject III: Algae.

| Organisation | Title |
|---|---|
| Technische Hochschule Aachen (D)<br>Università di Firenze (I) | Methane production by mariculture on land. |
| C.S.A.R.E. (I) | Exploitation of Lagoon macro-algae for biogas production. |
| Société Française des Pétroles BP (F) | Basic research on continuous cultivation of photosynthetic microbiological systems, using as a limiting substrate natural sunlight... |
| University of Nottingham (UK) | Biomass from offshore sea areas. |
| École Nationale Supérieure de Chimie de Paris (F) | Renewable hydrocarbon fuels by cultivation of the green alga Botryococcus braunii. Investigation of the factors affecting hydrocarbon production. |

## **Subject IV:** Biomass conversion (biological routes).

| Organisation | Title |
|---|---|
| University College Cardiff (UK) | Development of prototype units for the production of biogas methane from energy crops and farm wastes. |
| University College, Galway (EIR) | Methane from agricultural wastes and from energy crops. |
| Université Catholique de Louvain (B) | Pilot-scale methane production by anaerobic digestion of algae. |
| De Staat der Nederlanden (NL) | Two-phase process for the anaerobic digestion of organic wastes, yielding methane and compost. |
| De Staat der Nederlanden (NL) | The feasibility of thermophilic anaerobic digestion for methane generation from organic wastes. |
| National Institute of Applied Sciences of Toulouse (F) | New process for ethanol production, physiological and biotechnological studies of alcoholic fermentations. |
| Università degli Studi di Napoli (I) | Utilisation des déchets de l'agriculture comme source d'énergie. Saccharification des résidus cellulosiques par un procédé enzymatique à deux étapes. |
| De Staat der Nederlanden (NL) | Liquefaction and saccharification of agricultural biomass. |

## **Subject V:** Biomass conversion (thermochemical routes).

| Organisation | Title |
|---|---|
| The University of Nottingham (UK) | Final development of a large straw-fired furnace/heat exchanger system for use in grain drying. Small straw-fired system for farmhouses and premises. |
| Royal Veterinary and Agricultural University (DK) | The use of air scrubbers for heat extraction from straw furnaces. |
| Royal Veterinary and Agricultural University (DK) | Extraction of heat energy from animal waste by combined drying, combustion and water vapour condensation. |
| Queen Mary College, University of London (UK) | The high intensity combustion of straw bales to raise steam for power generation. |
| C.N.E.E.M.A. / Thirouard / S.A.R.L. Promill / Alsthom-Atlantique (F) | Réalisation d'un ensemble de granulation à chaud sur plateau semi-remorque et essais de longue durée sur le terrain. |
| Imbert — Energietechnik GmbH und CO Kommandit-Gesellschaft (D) | Development of downdraught gasification with oxygen and saturated steam to obtain synthetic gas - syngas - for the methanol synthesis. Capacity 1 000 kg wood with 20% by weight of $H_2O$. |
| Twente University of Technology (NL) | Gasification of biomass. |
| Novelerg (F) | Working, collecting and transformation of wood into methanol. Technical and economical study. |
| C.N.E.E.M.A. / Centre Techn. Forestier Tropical / Elf Aquitaine / Total Energie Développement / Creusot-Loire (F) | Development work prior to the construction of methanol synthesis units of 1 500 metric tons per day minimum, using biomass as a feedstock. |
| Creusot-Loire (F) | Process and equipment for the fluid bed oxygen gasification of wood and peat. |
| Foster Wheeler Power Products Ltd, London (UK) | Development of an optimised process to gasify biomass for further conversion to liquid fuels. |
| Université Catholique de Louvain (B) | Adaptation of a method to produce ligneous material to suit the requirements of a catalytic transformation into liquid fuels. |